the electrodynamic theory of light in which the author demonstrates the ascendency of Wilhelm Weber over James Clerk Maxwell and predicts that "the explanations furnished by the electronic theory . . . contain the germs of future progress in electric-light engineering." The reasons for this prophecy, however, are not disclosed.

After explaining what an arc is, the conditions under which it is formed and the method of adjustment the author describes the physical and chemical properties of typical electrode materials and the process of manufacture of carbon electrodes. This is followed by a brief discussion of the theory of electrical discharges based upon the electronic theory. In the fifth chapter the author reviews some of the investigations made upon spark discharges between electrodes of different shapes in air. The treatment of this subject seems scant and antiquated in view of the many pertinent investigations made during the past ten years. The effect of gas pressure, humidity, temperature and kind of gas is not considered.

The most valuable contributions to the subject are made in the last three chapters. The sixth chapter has to do with the voltage and current conditions in the direct and alternating-current carbon arc lamp, the seventh with the distribution of energy in carbon arc lamps and vapor tubes, and the eighth with the relation between power and light emitted by plain and mineralized carbon arc lamps and vapor tubes.

The author confesses that some of his remarks are of purely didactic nature, and these digressions, although prohibitive of smooth development of the subject, contain many valuable suggestions. In expressing his disapproval of the term "watts per candle" the author has anticipated the recent suggestion of the term "lumens per watt." In remarking that "physiological effects can no more be expressed in mechanical horse-power than can, for instance, Beethoven's 'Ninth Symphony'" it would seem, in view of the measurements reported by our modern nutrition laboratories, that the author might have chosen a less vulnerable example. The text at times seems to rise above the subject, the discussion in places being supported by cosmogonic reflections and the fourth dimension.

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SPECIAL ARTICLES

LIGHT AND THE RATE OF GROWTH IN PLANTS

A STUDY of the development of about a hundred seed-plants in darkness in an equable temperature chamber from 1900–03 in the New York Botanical Garden gave foundation for the following statement:

> The failure of a large proportion of the forms examined to make an accelerated or exaggerated growth when freed from the influence of light, even when provided with an adequate food-supply, shows that light has no invariable or universal relation to increase in length, or thickness or to the multiplication or increase in volume of separate cells.[1]

Precision appliances for the measurement of illumination and of other environmental conditions in daylight were not available at that time, and it was therefore not possible to follow the contrasting reactions which accompanied illumination and shading of the large plants which were the subjects in the extended experiments. In one series, however, the peduncles and scapes of *Arisaema* nearing the end of their period of elongation showed in initial acceleration when light was totally excluded from the plants. This acceleration reached its maximum in twenty-four hours then decreased to a minimum equivalent to the original rate in about four times this period. The older plump assertion that "light retards growth" continued to be cited without modification by writers of text-books and compendiums. The few investigators who turned attention to the subject have been content with referring to such cyclopedias. Thus Blaauw[2] says, in discussing positive and negative photogrowth reactions:

[1] MacDougal, "Influence of Light and Darkness on Growth and Development," *Mem. N. Y. Bot. Garden*, 2, pp. 307, 308, 1903.

[2] "The Primary Photogrowth Reaction and the Cause of the Positive Phototropism in *Phycomyces nitens*," Kon. Akad. van Wetensch. te Amsterdam. Proc. of meeting, January 31, 1914.

With regard to the existence of a sharply defined reaction of this kind, practically nothing can be deduced from literature references, at least the general opinion about the influence of light on growth is completely at variance with these facts. In the first place so far as concerns the positive or negative influence of light, the general conception, supported by numerous facts, is that light exercises a retarding influence on growth.

Blaauw's results which are described in the paper mentioned above and in a later paper[3] confirm my original thesis that light does not exercise a flat or invariable effect on growth. Furthermore Blaauw's beautifully arranged experiments by which sporangiophores of the mould were exposed to illumination from four or eight sides, with controlled intensities, demonstrate that the first reaction of this organ to a sudden illumination is an accelerated rate of growth, followed by a gradual decrease from which a recovery is made to the original rate. It is to be seen that the general mode of change is similar to that of massive organs deprived of light as described above. American reviewers seem to have been equally ignorant of my earlier experiments, which had the force of rendering the older generalization invalid. Furthermore the indirect effect of light in conditioning differentiations of tissues and thus affecting growth-elongations was pointed out. Blaauw has made an important contribution by his experimental analysis of the action of light on such simple structures as the sporangiophore of a mould.

The elongation or enlargement of a cell or of any structure like that of the sporangiophore of *Phycomyces* may be taken as the expression of inequality between the extensibility of the cell material, and its membrane, and of some internal expanding or stretching force. The osmotic pressure of the contents of the vacuoles, or of solutions filling the protoplasmic interstices has hitherto been relied upon to furnish the necessary force of growth.

Borowikov has recently established a parallel between the growth of certain seedlings in known definite solutions and the hydratation of colloids in the same solutions. This author is therefore led to believe that the stretching force of growth is not osmotic but hydratation pressure, and he relegates osmotic pressure, turgidity and its corollaries to an inconsequential place in the entire matter.[4]

Several features of the growth and hydratation of cacti are not without importance in connection with any consideration of this matter. The researches of Richards and of Spoehr at the Desert Laboratory show that the acidity (malic and oxalic) of the sap of cylindropuntias and platypuntias decreases from its maximum at daybreak to a minimum at about 4 P.M. in the open. The decrease has been shown to be due to the conjoint disintegrating action of temperature and chiefly of light. The calibrations made by Mr. E. H. Long (paper now in press) brought out the fact that if small cylinders were cut from the bodies of these cacti in series beginning at daybreak and extending to the period of minimum acidity, the hydratation capacity of the pieces increases independently of osmotic pressure throughout the day and is greatest in those which have been taken from the plant at the time when collateral tests would indicate the lowest acidity.

Extensive auxanometric records of *Opuntia Blakeana* made chiefly in March and April show that the growth of the enlarging joints is at a minimum in the morning, with a rapid acceleration parallel with the rising temperature of the open, reaching a maximum about noon and then decreasing to a minimum before 3 P.M. The curves of decreasing acidity and increasing hydratation capacity are symmetrical through the range of acidity from N/10 to N/20 according to available data obtained from these plants, and would probably sustain a similar relation in weaker solutions if the acidity were reduced still further.

From the records cited above however it is to be seen that the acceleration of the rate of growth does not follow that of hydratation to its customary daily maximum. Whether this divergence is due to a shrinkage following a heightened water-loss is not yet known. An ample supply was available to the absorbing

[3] "Light und Wachstum," *Zeitschr. f. Botanik.*, Hft. 8, 1914.

[4] Borowikow, "Ueber die Ursachen des Wachstums der Pflanzen," *Biochem. Zeitschrift*, 48: pp. 230–46, 1913.

surfaces within a few cm. of the expanding masses of cells, but local transpiration may have resulted in actual shrinkage. The optimum temperature for this plant is also a feature not yet determined.

The growth of the opuntias therefore takes place during a period of decreasing acidity resulting from the disintegrating action of light and rising temperatures. This statement applies not only to the diurnal behavior of the plants during the growing season, but to the growing season as a whole, which as Dr. H. M. Richards has pointed out in a paper now in press is one of diminishing acidity. The acidities of the cacti are calculated for the sap of the plants. The acidities of N/100 to N/3,000 found by Borowikow to be favorable for hydratation and growth were of the culture solution; that of the sap of the seedling used was probably still much lower.

Light and temperature in lesser degree are seen to exercise a totalized releasing effect on growth coincident with reduced acidity and increased hydratation, to a certain limit. Beyond this growth rate is checked. Further analytical tests will be necessary to determine the limiting factors.

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PROCEEDINGS OF THE ANNUAL MEETING OF THE AMERICAN SOCIETY OF ZOOLOGISTS HELD IN PHILADELPHIA, 1914. II

Multiple Human Births: G. H. PARKER.

Multiple births are well known among human beings and the proportions of twins, triplets, and quadruplets to single births have often been recorded. Instances of five and six children at a birth are very rare but apparently well authenticated. All cases above six are very doubtful. In the *Boston Medical and Surgical Journal*, Volume 10, page 224, 1872, is recorded from Trumbull County, Ohio, a case of eight children at a birth. This very circumstantial account, which has been quoted in numerous books and journals, proves on investigation by the county clerk of Trumbull County to be entirely fictitious.

Comparative and General Physiology

Effect of Electrolytes Upon the Rate of Nerve Conduction in Cassiopea: ALFRED G. MAYER.

Further Studies on the Behavior of Amœba: ASA A. SCHAEFFER.

The Significance of Certain Internal Conditions of the Organism in Organic Evolution: F. H. PIKE AND E. B. SCOTT.

Zoologists, while studying the phenomena of form regulation in animals, have given comparatively little thought to the regulation of internal conditions—the changes in matter and energy in the organisms which underly the changes of form.

The data accumulated in the physiological laboratories show that in the higher animals there is a regulation, varying within relatively narrow limits, of body temperature, the blood pressure, the tension of carbon dioxide and oxygen, of the concentration of hydrogen and hydroxyl ions, of the osmotic pressure, and of the general composition, quantitative as well as qualitative, of the fluids of the body, brought about by a number of systems and organs of the body.

From the point of view of the physical chemist, the general constancy of internal conditions of the higher organism may be interpreted in terms of chemical equilibrium. If the reactions within the body are of the nature of the "slow" reactions of the chemical laboratory, the constant temperature and the constant physico-chemical concentration of the body fluids would be attended by a speed of reaction within the body which would be, in a considerable degree, independent of the conditions in the environment. The internal mechanisms of the organisms lie at the base of the diminishing effect of the environment, or the greater degree of independence of the animal from the conditions of the environment as the organisms occupy successively higher positions in the evolutionary scale.

Experiments on X-Radiation as the Cause of Permeability Changes: A. RICHARDS.

Some Factors Concerned in the Death of Paramœcium at High Temperatures: M. H. JACOBS.

The Effect of Color in the Environment on the Color Changes of Anolis Carolinensis: MANTON COPELAND.

It is well known that the so-called *Florida chameleon, Anolis carolinensis* Cuv., becomes green in the dark and almost invariably turns brown in daylight. To test the effect of color in the environment on the color changes in the skin of the lizard, the animals were placed in boxes lined in part with colored paper and exposed to daylight. It was found that the green color was often assumed under such conditions. A yellow environment always induced a change from brown to